

SEQUENCE LISTING

<110> The Board of Control of
Michigan Technological University et al.

<120> GENETIC ENGINEERING OF LIGNIN BIOSYNTHESIS IN PLANTS

<130> 881.003WO1

<140>

<141> Herewith

<150> 08/969,046

<151> 1997-11-12

<160> 17

<170> FastSEQ for Windows Version 3.0

<210> 1

<211> 1915

<212> DNA

<213> Populus tremuloides Michx. (aspen)

<220>

<221> CDS

<222> (83)...(1687)

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aaa tta cca gac atc tac atc ccg aaa aac ctt ccc ctg cat tca tac 160
Lys Leu Pro Asp Ile Tyr Ile Pro Lys Asn Leu Pro Leu His Ser Tyr
15 20 25

gtt ctt gag aac ttg tct aaa cat tca tca aaa cct tgc ctg ata aat 208
Val Leu Glu Asn Leu Ser Lys His Ser Ser Lys Pro Cys Leu Ile Asn
30 35 40

ggc gcg aat gga gat gtc tac acc tat gct gat gtt gag ctc aca gca 256
Gly Ala Asn Gly Asp Val Tyr Thr Tyr Ala Asp Val Glu Leu Thr Ala
45 50 55

aga aga gtt gct tct ggt ctg aac aag att ggt att caa caa ggt gac 304
Arg Arg Val Ala Ser Gly Leu Asn Lys Ile Gly Ile Gln Gln Gly Asp
60 65 70

gtg atc atg ctc ttc cta cca agt tca cct gaa ttc gtg ctt gct ttc 352
Val Ile Met Leu Phe Leu Pro Ser Ser Pro Glu Phe Val Leu Ala Phe
75 80 85 90

cta ggc gct tca cac aga ggt gcc atg atc act gct gcc aat cct ttc 400
Leu Gly Ala Ser His Arg Gly Ala Met Ile Thr Ala Ala Asn Pro Phe
95 100 105

tcc acc cct gca gag cta gca aaa cat gcc aag gcc tcg aga gca aag 448
Ser Thr Pro Ala Glu Leu Ala Lys His Ala Lys Ala Ser Arg Ala Lys

00530653-02400

Sub
A1

110

115

120

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cga Arg	gaa Glu 140	agt Ser	gat Asp	gtt Val	aag Lys	gtc Val 145	atg Met	tgc Cys	gtg Val	gac Asp	tct Ser 150	gcc Ala	ccg Pro	gac Asp	ggg Gly	544
gct Ala 155	tca Ser	ctt Leu	ttc Phe	aga Arg	gct Ala 160	cac His	aca Thr	cag Gln	gca Ala	gac Asp 165	gaa Glu	aat Asn	gaa Glu	gtg Val	cct Pro 170	592
cag Gln	gtc Val	gac Asp	att Ile	agt Ser 175	cct Pro	gat Asp	gat Asp	gtc Val	gta Val 180	gca Ala	ttg Leu	cct Pro	tat Tyr	tca Ser 185	tca Ser	640
ggg Gly	act Thr	aca Thr	ggg Gly 190	ttg Leu	cca Pro	aaa Lys	ggg Gly 195	gtc Val	atg Met	tta Leu	acg Thr	cac His 200	aaa Lys	ggg Gly	cta Leu	688
ata Ile	acc Thr	agt Ser 205	gtg Val	gct Ala	caa Gln	cag Gln	gta Val 210	gat Asp	gga Gly	gac Asp	aat Asn 215	cct Pro	aac Asn	ctg Leu	tat Tyr	736
ttt Phe	cac His 220	agt Ser	gaa Glu	gat Asp	gtg Val	att Ile 225	ctg Leu	tgt Cys	gtg Val	ctt Leu	cct Pro 230	atg Met	ttc Phe	cat His	atc Ile	784
tat Tyr 235	gct Ala	ctg Leu	aat Asn	tca Ser	atg Met 240	atg Met	ctc Leu	tgt Cys	ggg Gly	ctg Leu 245	aga Arg	gtt Val	ggg Gly	gcc Ala	tcg Ser 250	832
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gag Glu	aag Lys	tac Tyr 270	aag Lys	gta Val	tct Ser	ata Ile	gca Ala 275	cca Pro	gtt Val	gtt Val	cca Pro	cct Pro	gtg Val 280	atg Met	atg Met	928
gca Ala	att Ile 285	gct Ala	aag Lys	tca Ser	cct Pro	gat Asp	ctt Leu 290	gac Asp	aag Lys	cat His	gac Asp	ctg Leu 295	tct Ser	tct Ser	ttg Leu	976
agg Arg	atg Met 300	ata Ile	aaa Lys	tct Ser	gga Gly	ggg Gly 305	gct Ala	cca Pro	ttg Leu	ggc Gly	aag Lys 310	gaa Glu	ctt Leu	gaa Glu	gat Asp	1024
act Thr 315	gtc Val	aga Arg	gct Ala	aag Lys	ttt Phe 320	cct Pro	cag Gln	gct Ala	aga Arg	ctt Leu 325	ggg Gly	cag Gln	gga Gly	tat Tyr	gga Gly 330	1072
atg Met	acc Thr	gag Glu	gca Ala	gga Gly 335	cct Pro	gtt Val	cta Leu	gca Ala	atg Met 340	tgc Cys	ttg Leu	gca Ala	ttt Phe	gcc Ala 345	aag Lys	1120
gaa Glu	cca Pro	ttc Phe 350	gac Asp	ata Ile	aaa Lys	cca Pro	ggg Gly	gca Ala 355	tgt Cys	gga Gly	act Thr	gta Val 360	gtc Val	agg Arg	aat Asn	1168

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 Asn Gln Pro Gly Glu Ile Cys Ile Arg Gly Asp Gln Ile Met Lys Gly
 380 385 390
 tat ctt aat gac ccc gag gca acc tca aga aca ata gac aaa gaa gga 1312
 Tyr Leu Asn Asp Pro Glu Ala Thr Ser Arg Thr Ile Asp Lys Glu Gly
 395 400 405 410
 tgg ctg cac aca ggc gat atc ggc tac att gat gat gat gat gag ctt 1360
 Trp Leu His Thr Gly Asp Ile Gly Tyr Ile Asp Asp Asp Asp Glu Leu
 415 420 425
 ttc atc gtt gac aga ttg aag gaa ttg atc aag tat aaa ggg ttt cag 1408
 Phe Ile Val Asp Arg Leu Lys Glu Leu Ile Lys Tyr Lys Gly Phe Gln
 430 435 440
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 Val Ala Pro Thr Glu Leu Glu Ala Leu Leu Ile Ala His Pro Glu Ile
 445 450 455
 tcc gat gct gct gta gta gga ttg aaa gat gag gat gcg gga gaa gtt 1504
 Ser Asp Ala Ala Val Val Gly Leu Lys Asp Glu Asp Ala Gly Glu Val
 460 465 470
 cct gtt gca ttt gta gtg aaa tca gaa aag tct cag gcc acc gaa gat 1552
 Pro Val Ala Phe Val Val Lys Ser Glu Lys Ser Gln Ala Thr Glu Asp
 475 480 485 490
 gaa att aag cag tat att tca aaa cag gtg atc ttc tac aag aga ata 1600
 Glu Ile Lys Gln Tyr Ile Ser Lys Gln Val Ile Phe Tyr Lys Arg Ile
 495 500 505
 aaa cga gtt ttc ttc att gaa gca att ccc aag gca cca tca ggc aag 1648
 Lys Arg Val Phe Phe Ile Glu Ala Ile Pro Lys Ala Pro Ser Gly Lys
 510 515 520
 atc ctg agg aag aat ctg aaa gag aag ttg cca ggc ata taactgaaga 1697
 Ile Leu Arg Lys Asn Leu Lys Glu Lys Leu Pro Gly Ile
 525 530 535
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<210> 2

<211> 535

<212> PRT

<213> Populus tremuloides Michx. (aspen)

<400> 2

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00420" E350E560

Lys His Ser Ser Lys Pro Cys Leu Ile Asn Gly Ala Asn Gly Asp Val
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 Tyr Thr Tyr Ala Asp Val Glu Leu Thr Ala Arg Arg Val Ala Ser Gly
 50 55 60
 Leu Asn Lys Ile Gly Ile Gln Gln Gly Asp Val Ile Met Leu Phe Leu
 65 70 75 80
 Pro Ser Ser Pro Glu Phe Val Leu Ala Phe Leu Gly Ala Ser His Arg
 85 90 95
 Gly Ala Met Ile Thr Ala Ala Asn Pro Phe Ser Thr Pro Ala Glu Leu
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 Ala Lys His Ala Lys Ala Ser Arg Ala Lys Leu Leu Ile Thr Gln Ala
 115 120 125
 Cys Tyr Tyr Glu Lys Val Lys Asp Phe Ala Arg Glu Ser Asp Val Lys
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 Val Met Cys Val Asp Ser Ala Pro Asp Gly Ala Ser Leu Phe Arg Ala
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 His Thr Gln Ala Asp Glu Asn Glu Val Pro Gln Val Asp Ile Ser Pro
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 Asp Asp Val Val Ala Leu Pro Tyr Ser Ser Gly Thr Thr Gly Leu Pro
 180 185 190
 Lys Gly Val Met Leu Thr His Lys Gly Leu Ile Thr Ser Val Ala Gln
 195 200 205
 Gln Val Asp Gly Asp Asn Pro Asn Leu Tyr Phe His Ser Glu Asp Val
 210 215 220
 Ile Leu Cys Val Leu Pro Met Phe His Ile Tyr Ala Leu Asn Ser Met
 225 230 235 240
 Met Leu Cys Gly Leu Arg Val Gly Ala Ser Ile Leu Ile Met Pro Lys
 245 250 255
 Phe Glu Ile Gly Ser Leu Leu Gly Leu Ile Glu Lys Tyr Lys Val Ser
 260 265 270
 Ile Ala Pro Val Val Pro Pro Val Met Met Ala Ile Ala Lys Ser Pro
 275 280 285
 Asp Leu Asp Lys His Asp Leu Ser Ser Leu Arg Met Ile Lys Ser Gly
 290 295 300
 Gly Ala Pro Leu Gly Lys Glu Leu Glu Asp Thr Val Arg Ala Lys Phe
 305 310 315 320
 Pro Gln Ala Arg Leu Gly Gln Gly Tyr Gly Met Thr Glu Ala Gly Pro
 325 330 335
 Val Leu Ala Met Cys Leu Ala Phe Ala Lys Glu Pro Phe Asp Ile Lys
 340 345 350
 Pro Gly Ala Cys Gly Thr Val Val Arg Asn Ala Glu Met Lys Ile Val
 355 360 365
 Asp Pro Glu Thr Gly Val Ser Leu Pro Arg Asn Gln Pro Gly Glu Ile
 370 375 380
 Cys Ile Arg Gly Asp Gln Ile Met Lys Gly Tyr Leu Asn Asp Pro Glu
 385 390 395 400
 Ala Thr Ser Arg Thr Ile Asp Lys Glu Gly Trp Leu His Thr Gly Asp
 405 410 415
 Ile Gly Tyr Ile Asp Asp Asp Asp Glu Leu Phe Ile Val Asp Arg Leu
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 Lys Glu Leu Ile Lys Tyr Lys Gly Phe Gln Val Ala Pro Thr Glu Leu
 435 440 445
 Glu Ala Leu Leu Ile Ala His Pro Glu Ile Ser Asp Ala Ala Val Val
 450 455 460
 Gly Leu Lys Asp Glu Asp Ala Gly Glu Val Pro Val Ala Phe Val Val
 465 470 475 480
 Lys Ser Glu Lys Ser Gln Ala Thr Glu Asp Glu Ile Lys Gln Tyr Ile
 485 490 495
 Ser Lys Gln Val Ile Phe Tyr Lys Arg Ile Lys Arg Val Phe Phe Ile
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 Glu Ala Ile Pro Lys Ala Pro Ser Gly Lys Ile Leu Arg Lys Asn Leu

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PCT/US98/24138

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<210> 3
<211> 1710
<212> DNA
<213> Populus tremuloides Michx. (aspen)
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<221> CDS
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Pro	Gln	Asn	Gln	Asn	Ala	Pro	Ser	Ser	His	Glu	Thr	Asp	His	Ile	Phe	
			20					25					30			
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Arg	Ser	Lys	Leu	Pro	Asp	Ile	Thr	Ile	Ser	Asn	Asp	Leu	Pro	Leu	His	
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att	tca	ggt	tcc	acg	gga	aaa	acc	tat	tct	ttt	gcc	gaa	act	cac	ctc	240
Ile	Ser	Gly	Ser	Thr	Gly	Lys	Thr	Tyr	Ser	Phe	Ala	Glu	Thr	His	Leu	
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ata	tct	cgg	aag	gtc	gct	gct	ggg	tta	tcc	aat	ttg	ggc	atc	aag	aaa	288
Ile	Ser	Arg	Lys	Val	Ala	Ala	Gly	Leu	Ser	Asn	Leu	Gly	Ile	Lys	Lys	
				85					90					95		
ggc	gat	gta	atc	atg	acc	ctg	ctc	caa	aac	tgc	cca	gaa	ttc	gtc	ttc	336
Gly	Asp	Val	Ile	Met	Thr	Leu	Leu	Gln	Asn	Cys	Pro	Glu	Phe	Val	Phe	
			100					105					110			
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Ser	Phe	Ile	Gly	Ala	Ser	Met	Ile	Gly	Ala	Val	Ile	Thr	Thr	Ala	Asn	
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Pro	Phe	Tyr	Thr	Gln	Ser	Glu	Ile	Phe	Lys	Gln	Phe	Ser	Ala	Ser	Arg	
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Ala	Lys	Leu	Ile	Ile	Thr	Gln	Ser	Gln	Tyr	Val	Asn	Lys	Leu	Gly	Asp	
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Ser	Asp	Cys	His	Glu	Asn	Asn	Gln	Lys	Pro	Gly	Glu	Asp	Phe	Ile	Val	
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atc	acc	att	gat	gac	ccg	cca	gag	aac	tgt	cta	cat	ttc	aat	gtg	ctt	576
Ile	Thr	Ile	Asp	Asp	Pro	Pro	Glu	Asn	Cys	Leu	His	Phe	Asn	Val	Leu	

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gga gtg ata ctg acc cac aag agc ttg ata aca agt gtg gct caa caa Gly Val Ile Leu Thr His Lys Ser Leu Ile Thr Ser Val Ala Gln Gln 225 230 235 240			720
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tta tgc tcg ttg aga gcc ggt tct gct gtt ctt tta atg caa aag ttt Leu Cys Ser Leu Arg Ala Gly Ser Ala Val Leu Leu Met Gln Lys Phe 275 280 285			864
gag ata gga tca ctg cta gag ctc att cag aaa cac aat gtt tcg gtt Glu Ile Gly Ser Leu Leu Glu Leu Ile Gln Lys His Asn Val Ser Val 290 295 300			912
gcg gct gtg gtg cca cca ctg gtg ctg gcg ttg gcc aag aac cca ttg Ala Ala Val Val Pro Pro Leu Val Leu Ala Leu Ala Lys Asn Pro Leu 305 310 315 320			960
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gcg cca ctg ggg aag gag ctc gag gac gcc ctc agg agc agg gtt cct Ala Pro Leu Gly Lys Glu Leu Glu Asp Ala Leu Arg Ser Arg Val Pro 340 345 350			1056
cag gcc atc ctg gga cag ggt tat ggg atg aca gag gcc ggg cct gtg Gln Ala Ile Leu Gly Gln Gly Tyr Gly Met Thr Glu Ala Gly Pro Val 355 360 365			1104
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atc cgt gga tcc caa atc atg aaa gga tat ttg aat gac gcg gaa gcc Ile Arg Gly Ser Gln Ile Met Lys Gly Tyr Leu Asn Asp Ala Glu Ala 420 425 430			1296

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7

acg gca aac acc ata gac gtt gag ggt tgg ctc cac act gga gat ata 1344
 Thr Ala Asn Thr Ile Asp Val Glu Gly Trp Leu His Thr Gly Asp Ile
 435 440 445

ggt tat gtc gac gac gac gac gag att ttc att gtt gat aga gtg aag 1392
 Gly Tyr Val Asp Asp Asp Asp Glu Ile Phe Ile Val Asp Arg Val Lys
 450 455 460

gaa atc ata aaa ttc aaa ggc ttc cag gtg ccg cca gcg gag ctt gag 1440
 Glu Ile Ile Lys Phe Lys Gly Phe Gln Val Pro Pro Ala Glu Leu Glu
 465 470 475 480

gct ctc ctt gta aac cac cct tca att gcg gat gcg gct gtt gtt ccg 1488
 Ala Leu Leu Val Asn His Pro Ser Ile Ala Asp Ala Ala Val Val Pro
 485 490 495

caa aaa gac gag gtt gct ggt gaa gtt cct gtc gcg ttt gtg gtc cgc 1536
 Gln Lys Asp Glu Val Ala Gly Glu Val Pro Val Ala Phe Val Val Arg
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tca gat gat ctt gac ctt agt gaa gag gct gta aaa gaa tac att gca 1584
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aag cag gtg gtg ttc tac aag aaa ctg cac aag gtg ttc ttc gtt cat 1632
 Lys Gln Val Val Phe Tyr Lys Lys Leu His Lys Val Phe Phe Val His
 530 535 540

tct att ccc aaa tcg gct tct gga aag att cta aga aaa gac ctc aga 1680
 Ser Ile Pro Lys Ser Ala Ser Gly Lys Ile Leu Arg Lys Asp Leu Arg
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 565 570

<210> 4

<211> 570

<212> PRT

<213> Populus tremuloides Michx. (aspen)

<400> 4

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 35 40 45
 Ala Tyr Cys Phe Glu Asn Leu Ser Asp Phe Ser Asp Arg Pro Cys Leu
 50 55 60
 Ile Ser Gly Ser Thr Gly Lys Thr Tyr Ser Phe Ala Glu Thr His Leu
 65 70 75 80
 Ile Ser Arg Lys Val Ala Ala Gly Leu Ser Asn Leu Gly Ile Lys Lys
 85 90 95
 Gly Asp Val Ile Met Thr Leu Leu Gln Asn Cys Pro Glu Phe Val Phe
 100 105 110
 Ser Phe Ile Gly Ala Ser Met Ile Gly Ala Val Ile Thr Thr Ala Asn
 115 120 125
 Pro Phe Tyr Thr Gln Ser Glu Ile Phe Lys Gln Phe Ser Ala Ser Arg

09530663-01400

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Ala Lys Leu Ile Ile Thr Gln Ser Gln Tyr Val Asn Lys Leu Gly Asp				
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Ser Asp Cys His Glu Asn Asn Gln Lys Pro Gly Glu Asp Phe Ile Val				
	165		170	
Ile Thr Ile Asp Asp Pro Pro Glu Asn Cys Leu His Phe Asn Val Leu				
	180		185	
Val Glu Ala Ser Glu Ser Glu Met Pro Thr Val Ser Ile Leu Pro Asp				
	195		200	
Asp Pro Val Ala Leu Pro Phe Ser Ser Gly Thr Thr Gly Leu Pro Lys				
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Gly Val Ile Leu Thr His Lys Ser Leu Ile Thr Ser Val Ala Gln Gln				
225		230		235
Val Asp Gly Glu Ile Pro Asn Leu Tyr Leu Lys Gln Asp Asp Val Val				
	245		250	
Leu Cys Val Leu Pro Leu Phe His Ile Phe Ser Leu Asn Ser Val Leu				
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Leu Cys Ser Leu Arg Ala Gly Ser Ala Val Leu Leu Met Gln Lys Phe				
	275		280	
Glu Ile Gly Ser Leu Leu Glu Leu Ile Gln Lys His Asn Val Ser Val				
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Ala Ala Val Val Pro Pro Leu Val Leu Ala Leu Ala Lys Asn Pro Leu				
305		310		315
Glu Ala Asn Phe Asp Leu Ser Ser Ile Arg Val Val Leu Ser Gly Ala				
	325		330	
Ala Pro Leu Gly Lys Glu Leu Glu Asp Ala Leu Arg Ser Arg Val Pro				
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Gln Ala Ile Leu Gly Gln Gly Tyr Gly Met Thr Glu Ala Gly Pro Val				
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Leu Ser Met Cys Leu Ala Phe Ser Lys Gln Pro Phe Pro Thr Lys Ser				
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Pro Glu Thr Gly Arg Ser Leu Gly Tyr Asn Gln Pro Gly Glu Ile Cys				
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Ile Arg Gly Ser Gln Ile Met Lys Gly Tyr Leu Asn Asp Ala Glu Ala				
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Thr Ala Asn Thr Ile Asp Val Glu Gly Trp Leu His Thr Gly Asp Ile				
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Gly Tyr Val Asp Asp Asp Asp Glu Ile Phe Ile Val Asp Arg Val Lys				
	450		455	
Glu Ile Ile Lys Phe Lys Gly Phe Gln Val Pro Pro Ala Glu Leu Glu				
465		470		475
Ala Leu Leu Val Asn His Pro Ser Ile Ala Asp Ala Ala Val Val Pro				
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Gln Lys Asp Glu Val Ala Gly Glu Val Pro Val Ala Phe Val Val Arg				
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	515		520	
Lys Gln Val Val Phe Tyr Lys Lys Leu His Lys Val Phe Phe Val His				
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<211> 1172

<212> DNA

<213> Populus tremuloides Michx. (aspen)

005066 01100

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tgattgatta	ttctctgtaa	ttttgtgaaa	tagattaaaa	cagctcaatg	tgaggtgacc	300
agttgtcaaa	tgaccactcg	acttggggca	tggtgatttt	tcaaatcaca	actcaatttg	360
aaaactaaaa	ttaaaaaaga	tttagattat	taaattatta	ggtaattca	cgggttggct	420
aatcaattat	tattaattaa	aacgatagta	tttttgataa	tttaattaaa	attttattgg	480
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taattgggct	agatttaaca	gctattattc	aaactggcca	ggacaattat	taaaattaat	660
aattattatt	ttttctaata	aagcacttcc	taattgttaa	aatatatgtc	taaacactaa	720
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<211> 1180

<212> DNA

<213> Populus tremuloides Michx. (aspen)

<400> 6

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<211> 12

<212> PRT

<213> Populus tremuloides Michx. (aspen)

<400> 7

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